ThS 2d.1: Risks related to surface & subsurface energy systems

Environmental implications of black shale weathering in the Grand Duchy of Luxembourg

Valérie Cappuyns; Pieter Geris; Rudy Swennen

KU Leuven, BE

The attention for black shale formations increased in recent years because of their potential for CO2 storage. Another potential concern is their enrichment with potentially toxic elements (PETs), which may be of environmental concern upon weathering of the shales. A comprehensive study of the so-called Schistes à Carton, a black shale formation occurring in the south-west of the in the Grand Duchy of Luxembourg was performed. Three weathering profiles, drilled from the soil surface till the fresh bedrock were investigated in detail to understand (i) the changes in mineralogy as a function of depth in comparison to the mineralogy of the bedrock; (ii) the elemental distribution of major and trace elements within the weathering profiles; (iii) the availability of trace elements within the soil overlying the black shales.

Besides geochemical analysis (major and trace elements, organic and inorganic carbon content, pH), the mineralogy of the Schistes à Carton was investigated by microscopy and X-ray diffraction. The relation between the mineralogy and the distribution of (trace) elements was deduced from FEG-EPMA analyses. The leaching of trace elements was determined by the application of leaching tests (pHstat tests and pH depended leaching tests) and single extractions (with NH4-EDTA, HOAc and CaCl2).

The mineralogy of the Schistes à Carton bedrock consists mainly of illite and kaolinite, quartz, calcite and pyrite. At a depth of 4.25 m, the bedrock starts to be affected by chemical, oxidizing weathering processes as pyrite is altered to goethite and gypsum. Gypsum is only precipitated till a depth of around 1.50 m. The acidity generated by pyrite oxidation is neutralized by calcite dissolution, resulting in neutral to slightly alkaline pH conditions.

The elemental distribution and enrichment factors within the weathered shales and at the soil surface indicate an increase in concentration for As, Cd, Fe, Mo, Ni, Pb and Zn towards the surface, in comparison to the chemical composition of the bedrock (background level). Most of these elements are not leached from the shales in the prevailing pH conditions (7 - 7.5), except Ni and Mo. Most PETs are co-precipitated in goethite and adsorbed on clays, goethite and organic matter. The elevated concentrations of Pb and Zn are

thought to be (partly) related to the presence of an anthropogenic pollution source (nearby steel plant). The Mo concentrations within the weathered shales were significantly higher (up to 75 mg kg-1) than worldwide background concentrations. The weathering of the Schistes à Carton implies only low environmental risks for the majority of the PTEs as they are co-precipitated in goethite and adsorbed on clays, goethite and organic matter upon weathering. The risk is medium for Ni and Mo as they are mobile at circumneutral pH conditions. This type of investigations is a useful basis for the further development of soil legislation in Luxemburg, and shows the importance of subsurface composition and its influence on soil geochemistry.